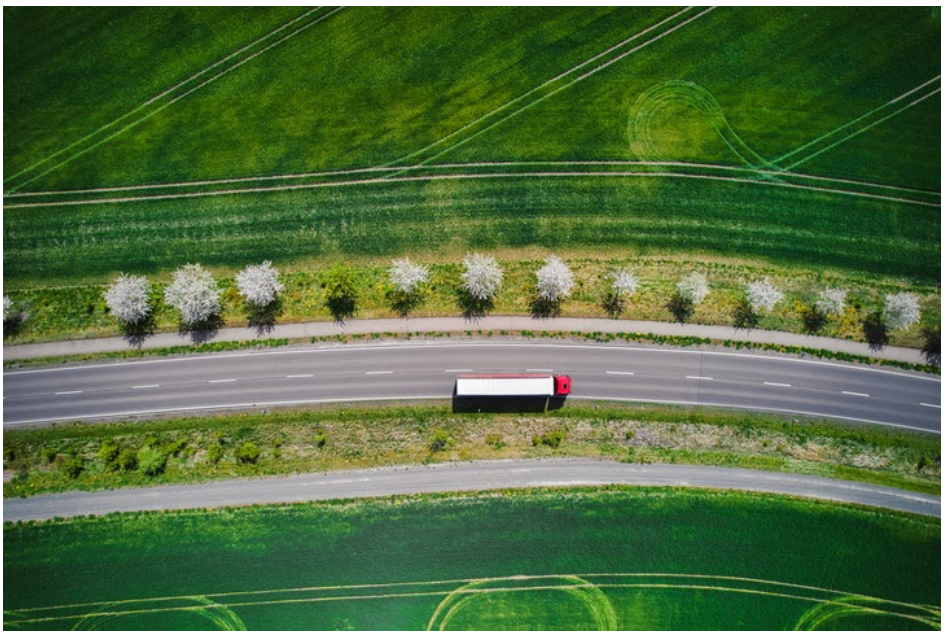
Top of the Bench 2023 Practical Challenge

SUSTAINABLE ENERGY



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Of the 32 million cars licensed in the UK in 2021 58% were petrol and 37% diesel.[1]

When burnt in a combustion engine, petrol and diesel release large quantities of carbon dioxide. Other pollutants such as unburnt hydrocarbons, carbon monoxide and particulate matter or soot are also produced.

Carbon dioxide is a greenhouse gas. Britain has a legal target to cut greenhouse gas emissions to net zero by 2050. In one step towards achieving this goal the sale of all new petrol and diesel cars will be banned from 2030.

One of the biggest challenges for future generations of chemists is to find alternatives to petrol and diesel for powering vehicles.

In this activity your team will:

- investigate three alternative fuels
- conclude which of the three fuels would be the best alternative to using petrol

1. Data from https://www.nimblefins.co.uk/cheap-car-insurance/number-cars-great-britain Accessed December 2022

Investigation 1 - Energy content per gram of fuel

Introduction

The energy content of a fuel can be determined using calorimetry (*calor* - heat; *meter* - instrument for measuring).

In calorimetry the energy released from burning a fuel is used to heat a known mass of water.

The specific heat capacity of water is 4.2 J / g ºC. This means that it takes 4.2 J of energy to raise the temperature of 1 g of water by 1 ºC.

To calculate the energy transferred to the water when the fuel is burnt, the following equation is used:

Energy transferred in J = mass of water in g × 4.2 J / g ºC × temperature change in ºC

The energy released **per gram** of fuel burnt is used to compare fuels.

The energy transferred per gram of fuel is calculated using the equation;

$$\text{Energy transferred per gram of fuel in J / g} = \frac{\text{Energy transferred to the water in J}}{\text{Mass of fuel burnt in g}}$$

In this investigation you will compare the energy transferred per gram for three different fuels, **Fuel A**, **Fuel B** and **Fuel C**.

Instructions

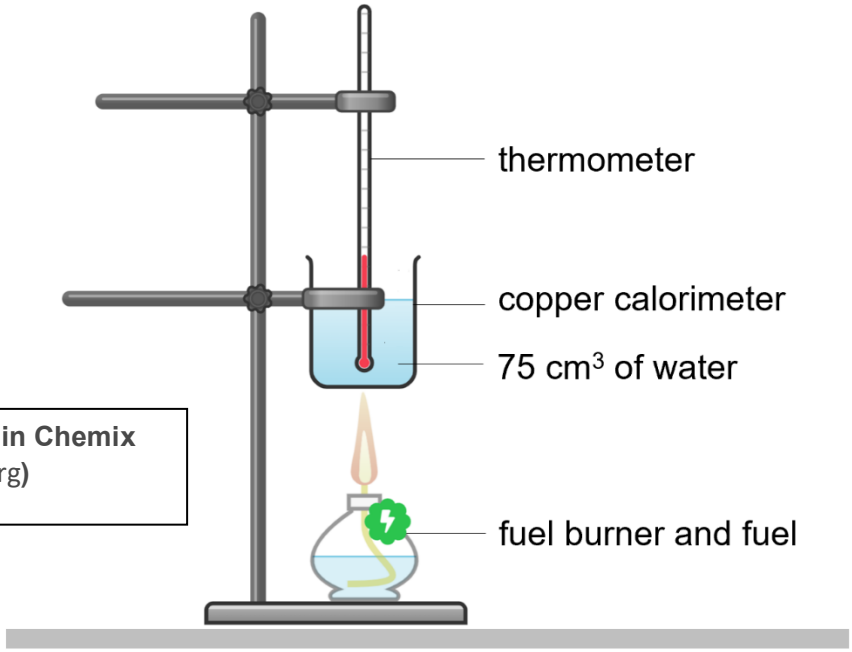
All results and answers should be written in the Answer booklet.

A basic method for the investigation is given on the next page.

You should;

1. Read the method.
2. Draw a table for your results.
3. Carry out the practical.
4. Record the results in your result's table.
5. Calculate the energy content per gram of each fuel.
   Give full working for your calculations.

Method



Diagrams made in Chemix
(https://chemix.org**)**

1. Carefully transfer 75 cm^3 of water (*density of water = 1 g/cm^3*) into the copper calorimeter.
2. Record the mass of the fuel burner and lid containing **Fuel A**.
3. Place the fuel burner on the base of a clamp stand.
4. Place the clamp stand on a heat proof mat.
5. Clamp the copper calorimeter so that its base is about 1.5 cm above the wick of the fuel burner.
6. Clamp a thermometer in place and record the initial temperature of the water in the calorimeter.
7. Remove the lid of the fuel burner and light the wick with a match.
8. Stir the water in the copper calorimeter at regular intervals.
9. When the temperature of the water has risen by about 30 ºC extinguish the flame. Replace the lid.
10. Record the new mass of the fuel burner and lid.
11. Record the maximum temperature of the water.
12. Calculate the **mass of fuel burnt** in grams.
13. Calculate the **temperature change** of the water in ºC.
14. Calculate the energy transferred per gram of **Fuel A** burnt.
15. Repeat steps 1-14 for **Fuel B** and **Fuel C**.

Investigation 2 – Density of Fuel A

Introduction

The average volume of a car's fuel tank is 55 000 cm^3.

Density is a measure of the amount of mass in a unit of volume.

The more dense the fuel the greater the mass of fuel that can be held in the fuel tank.

Table 1 gives the density of **Fuel B** and **Fuel C**.

Table 1

Fuel	Density in g / cm^3
A	?
B	0.79
C	0.81

In this investigation you will determine the density of **Fuel A**.

Method

Density is measured in units of g / cm^3.

It is calculated using the equation;

$$\text{Density in g / cm}^3 = \frac{\text{mass in g}}{\text{volume in cm}^3}$$

You are provided with a range of pieces of equipment for measuring volume as well as a balance for measuring mass.

Use the equipment provided to determine the density of **Fuel A** as accurately as you can.

Instructions

All results and answers should be written in the Answer booklet.

You should;

1. Choose the best equipment to measure volume accurately.
   Explain your choice.
2. Plan a method to determine the density of Fuel A.
3. Carry out your plan.
4. Record your results in a suitable table.
5. Calculate the density of Fuel A.

Final decision

Further information about each fuel is provided in **Table 2.**

Table 2

	Made from	**Can it be used in existing combustion engines?**	**Cost in £ per litre**
Fuel A	Currently produced industrially from ethene but new technology is being developed that will allow it to be produced from CO_2 and H_2O.	Not yet known	£6.80
Fuel B	Obtained by fermentation	All existing combustion engines can operate with fuels containing up to 15% Fuel B mixed with petrol.	£2.37
Fuel C	Obtained by fermentation	All existing combustion engines can operate with blends up to 85% Fuel C mixed with petrol	£4.52

Which fuel is the best alternative to petrol and diesel?

Give **two** reasons for your choice.

Use the results of **Investigation 1**, **Investigation 2** and **Table 2**.

Write your answer in the **Answer booklet**.

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Answer Booklet

School name: _____

Demonstrator comments:

Investigation 1 - Energy content per gram of fuel

Record your results for Investigation 1 in a suitable table in the space below;

ROYAL SOCIETY OF CHEMISTRY

Use your results to calculate the energy transferred per gram of each fuel.

Show all working in the space below;

Calculations for Fuel A

Energy transferred by Fuel A = _____ J / g

Calculations for Fuel B

Energy transferred by Fuel B = _____ J / g

Calculations for Fuel C

Energy transferred by Fuel C = _____ J / g

Investigation 2 – Density of Fuel A

Choose from the list below the equipment you chose to measure a set volume of **Fuel A**.

Tick one or more than one option.

Explain the reason for your choice.

Equipment choice

5 cm^3 graduated pipette ☐

10 cm^3 graduated pipette ☐

10 cm^3 measuring cylinder ☐

50 cm^3 measuring cylinder ☐

Explanation

Describe your method for determining the density of Fuel A.

Results

Record all measurements used to determine the density of **Fuel A** in a suitable table below.

Use your results to calculate the density of **Fuel A**.

Density of Fuel A _____ g / cm^3

Final decision

Which fuel is the best alternative to petrol and diesel?

Tick **one** fuel;

☐ **Fuel A** ☐ **Fuel B** ☐ **Fuel C**

Give **two** reasons that support your decision.

Reason 1 _____

_____

_____

_____

_____

_____

Reason 2 _____

_____

_____

_____

_____

_____